

Effects of beer-battering on the frying properties of rice and wheat batters and their coated foods

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Abstract

BACKGROUND: Beer in batter formulation or beer-battering has been popular in fried food recipes, but the topic is rarely reported in scientific journals or the claims substantiated with reliable studies. In this research, we prepared and characterized rice and wheat batters with and without using beer to replace water in the formulation. We studied and provided data on the effect of beer on the frying properties of batter and its coated foods.

RESULTS: With beer in the formulation, oil uptake of fried batters generally increased by up to 18%. Instrumental textural analyses indicate that beer-battering treatment generally decreased the hardness, increased the fracturability and improved the crispness of the fried batters. Sensory evaluations show similar trends, though to a lesser extent, that fish and onion rings coated with batters were softer but crispier with beer than without.

CONCLUSION: In general, beer-battering caused an increase in the oil uptake of the batter during frying. It also made the texture of fried batters slightly softer and crispier. The effects are more pronounced for rice batters than wheat batters.

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Keywords: beer-battering; rice batters; food coating; textural analysis; sensory evaluations

INTRODUCTION

Beer in food cooking provides unique characteristics, as the hop content of beer adds bitterness and acidity, the malt content adds a subtle sweetness, and the yeast content produces a light, fluffy texture. It is especially desirable for use in batters, and beer-battering has been popular in fried foods, particularly for seafood products.^{1,2}

Fried batters enhance food sensory quality, but they can also be a health concern. Fish or vegetables contain little fat, for instance, but the batter that coats the food could soak up substantial amounts of oil during frying. As excessive oil consumption is known to cause health problems, oil uptake in fried batters has been studied extensively in recent years.^{3–5} In earlier work, we developed gluten-free fried batters, containing exclusively rice ingredients.^{6,7} In addition to having overall frying properties comparable to those of the traditional wheat batters, the products had substantially lower oil uptake during frying. Recently, batter formulations containing beer have also been reported to result in slightly lower oil absorption.⁸

The prevalence of celiac disease (CD), an intolerance of gluten, has been reported to be as high as one in 200 of the world population.⁹ CD is a serious health issue and a challenge for food scientists, because it can only be treated by strict adherence to a gluten-free diet. Rice is naturally gluten-free and rice ingredients have been used to prepare gluten-free products that are traditionally made with wheat.¹⁰ Thus it is of interest

particularly to study the beer-battering effect using gluten-free beer on the frying properties of rice batters.

In the present study, rice and wheat batters were prepared with and without using beer to replace water in the formulation. The batters were fried and they were also used to coat foods. Their frying properties, including oil uptake, textural and sensory properties, were analyzed and evaluated.

MATERIALS AND METHODS

Materials

Long-grain rice flour (RL) and pre-gelatinized rice flour (PGRF, Remyflo R500P) were provided by Riceland (Stuttgart, AR, USA) and A&B Ingredients (Fairfield, NJ, USA), respectively. Purchased from local markets were Vidalia onions, frozen tilapia fillets, wheat flour (Gold Medal all purpose flour, General Mills Sales, Inc., Minneapolis, MN, USA), gluten-free beer (Redbridge, Anheuser-Busch, Inc., St Louis, MO, USA) and canola oil (Crisco, Orrville, OH, USA). All other ingredients used were of food grade and safe for human consumption.

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Table 1. Composition of batter slurries with comparable viscosity at about 120 RVU (1440 cps)

Batter slurries	Solid mixture (g) ^a	Water (g)	Beer (g)
RFW	Flour A 95.28	104	Y
RFB	Flour A 95.28		106
MRW	Flour B 95.28	104	
MRB	Flour B 95.28		106
WFW	Flour C 95.28	130	
WFB	Flour C 95.28		130

^a Common ingredients including sodium bicarbonate (1 g), sodium chloride (3 g) and sodium pyrophosphate (0.72 g).

Flour A: Long-grain rice flour; Flour B: long-grain rice flour (950 g kg⁻¹) and PGRF (50 g kg⁻¹); Flour C: wheat flour.

Preparation and frying of batters

A solid mixture was prepared containing common ingredients (10 g kg⁻¹ sodium bicarbonate, 30 g kg⁻¹ sodium chloride and 72 g kg⁻¹ sodium pyrophosphate) and 952.8 g kg⁻¹ flour (wheat flour, RL, or a mixture of RL and 50 g kg⁻¹ PGRF). Batter slurries were prepared by adding various amounts of water or beer to the solid mixture to achieve a viscosity of about 120 RVU (1440 cps) as shown in Table 1.

A 5.7 L Dazey deep-fryer (Dazy Co, New Century, KS, USA) with a strainer was used for the frying experiment. Heating was controlled by a controller, Therm-O-Watch L6 (Instruments for Research and Industry, Cheltenham, PA, USA). The oil bath, filled to a depth of 4.5 cm with 1.4 L vegetable oil, was heated to 190 °C. Batters were fried for various times depending on batter formulations to achieve the well-cooked golden brown outlook. Fried batters were drained on a strainer and cooled before being analyzed.

Preparation of coated fried foods

Frozen fillets were thawed and cut into 3.8 × 3.8 cm squares; onions were cut into 3.2 × 0.6 cm strips. Batter slurries as prepared above were used to coat the food evenly and fried using frying conditions as above. Samples coated in batters were fried until they were done. For those with water (RFW, MRW, WFW), the frying time was 4 min and for those with beer (RFB, MRB, WFB), it was 2 min. Fried samples were cooled before being analyzed.

Oil analysis

Oil content was analyzed using a supercritical fluid extraction system (SFX 220, ISCO, Lincoln, NB, USA). The sample cartridge was loosely filled with 1 g of Ottawa sand (EM Science, Gibbstown, NJ, USA) at the exit end of the cartridge, followed by 1 g of diatomaceous earth and 1.5–3.0 g of ground batter until the cartridge was full. Carbon dioxide (65 mL) was used to extract the sample at 51.71 MPa and 100 °C, and the restrictors were set at 140 °C. The flow rate was 2.5–2.7 mL min⁻¹. The oil content was calculated from the weight gain of the oil collected in tubes packed with 1.5 g of glass wool during the extraction.

Textural analysis

Textural properties were tested on a Steven's QTS Texture Analyzer (Brookfield Engineering Labs, Inc., Middleboro, MA, USA) with a 25 kg load cell. A 6.4 mm acrylic cylinder probe was used in a double bite test at 60 mm min⁻¹ test speed until an 80% deformation target was reached. The texture was measured after

cooling samples for 15 min. Textural properties were calculated with Texture Pro software from Brookfield Engineering Labs, Inc. Properties recorded included hardness, defined as the peak compression force attained during the first cycle of the force deformation curve, and quantity of fractures defined as the number of occasions the load decreased by 5% prior to reaching the target value in cycle 1.¹¹

Sensory evaluation

Descriptive texture evaluation was used to examine the sensory properties of the fried batter samples.¹² Eight panelists, trained in the principles and concepts of the analysis, participated in the sensory evaluation phase.⁶ Each panelist received four strips of coated fish or onion samples. They were evaluated for attributes of hardness, fracturability, crispness and toothpacking according to Meilgaard *et al.*¹² Definitions and scales of the attributes are given in Table 3. Scores were recorded on a computerized ballot system using Compusense Five (Compusense Inc. Guelph, Ontario, Canada).

Statistical analysis

Experimental design for the sensory data was a randomized complete block design with panelists as blocks. Analysis of variance was accomplished on each sensory attribute with PROC MIX (SAS, Enterprise Guide 4, 2006, Cary, NC, USA). Tukey's HSD (honestly significant difference) was used for mean comparisons with the α -level set at 0.1.

RESULTS AND DISCUSSION

In preliminary experiments, we compared the use of regular and gluten-free beers and found no difference between them in our investigation (results not shown). Gluten-free beer is used for all the following experiments. As a result, the food system is gluten-free when only rice batters are also used.

Oil uptake

Table 2 shows results of the oil uptake for fried batters with and without beer in the formulation. As expected, with or without beer, rice batters had substantially lower oil uptakes than wheat batters, by an average of about 50%. The gluten in wheat, being a protein, is relatively hydrophobic and lipophilic, which caused the wheat batters to absorb more oil during frying than the gluten-free rice batters. Similarly, because alcohol is more lipophilic than water, fried batters generally had higher oil contents with beer than without. Specifically, with beer-battering treatment, the oil uptake

Table 2. Oil content of fried batters

Sample	Flour	Solvent	Oil content (g kg ⁻¹ ± SD)
RFW	Rice	Water	266.5 ± 1.7a
RFB	Rice	Beer	289.9 ± 1.8a
MRW	Rice with 5% PGRF	Water	261.5 ± 21.1a
MRB	Rice with 5% PGRF	Beer	309.1 ± 20.4b
WFW	Wheat	Water	531.3 ± 25.8c
WFB	Wheat	Beer	593.9 ± 17.8d

Means of oil contents followed by the same letter are not significantly different.

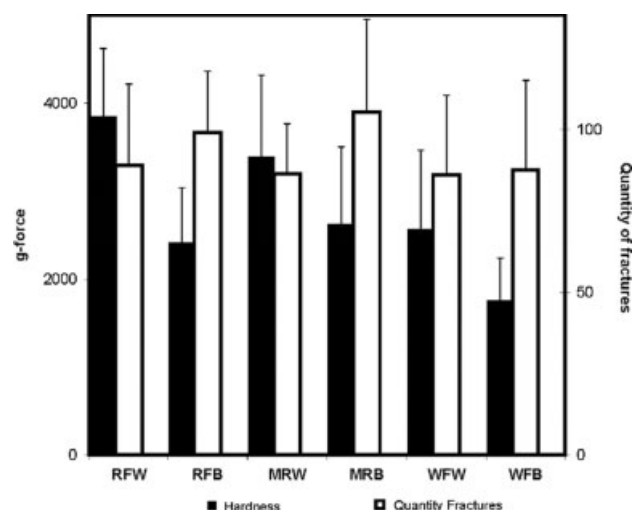


Figure 1. Effects of beer-battering on the instrumental textural properties of hardness and quantity of fractures for fried batters.

of wheat batters increased by about 12%. For rice batters, the increases were about 18% and 9%, with and without the additive PGFRF, respectively. Most likely, the added PGFRF functioned as a thickener, emulsifier or leavening-enhancing agent, as reported in the literature for gums and other polysaccharides in fried batters and bakery products.^{7,13,14} It caused the increase in oil uptake by making the network more porous and accessible to oil absorption.^{13,15} Nevertheless, even with the increase, the oil uptake of rice batters remained much lower than that of the wheat batters with or without beer in the formulation.

Textural properties

Effects of beer-battering on instrumental textural properties are shown in Fig. 1 for the fried batters. Invariably, with beer in the formulation, hardness decreased. On the other hand, quantity of fractures generally increased with beer-battering. Both hardness and fracturability are factors that contribute to the crispness of the fried batter. Using traditional wheat batters as acceptable quality controls, hardness ranging from 1700 to 2900 g force is desirable, whereas increased fractures normally enhances the development of superior crispness. Typically, samples (a) and (b) in Fig. 2 are fried batters WFW and MRB, respectively, that are prepared under conditions shown in Tables 1 and 2. Sample (a) (fried batter WFW) was determined to have a hardness value at 2905 g-force and fracture value at 56. Sample (b) (fried batter MRB) had a hardness value at 2084 g force and fracture value at 135. Fracture profiles of these two fried batters as shown in Fig. 2 indicate that at typical hardness values fracture values increased from sample (a) at 56 to sample (b) at 135, resulting in enhanced sample crispness.

Specifically, effects of beer-battering on the fried wheat batters appeared to be minimal, with changes in hardness ranging from 1757 g force with beer to 2558 g force without, and quantity of fractures remaining practically unchanged at about 82–87 with or without beer. The high oil content with or without beer could soften the fried wheat batters and minimize the effect of beer on the resulting textural properties.

Effects of beer on rice batters appeared to be more pronounced. For the fried batter with no PGFRF, hardness decreased from 3848 g force without beer to 2409 g force with beer, and quantity of fractures increased from 89 without beer to 99 with beer, making

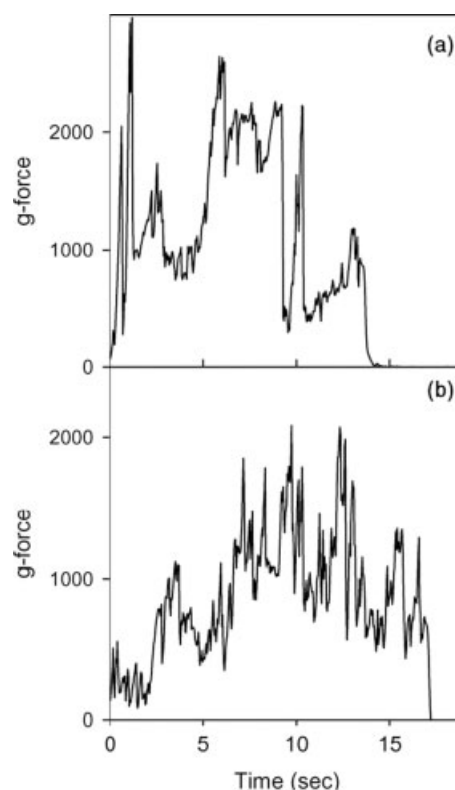


Figure 2. Fracture profiles of two fried batters with typical hardness values (1700–2900 g force) and various fracture values for samples: (a) WFW at 56 and (b) MRB at 135.

them more comparable in hardness to the traditional wheat counterparts. On the other hand, for rice batters with PGFRF, beer-battering caused a slight decrease in hardness and an increase in fracture. At 50 g kg⁻¹ PGFRF, the fried rice batter appeared to have superior textural characteristics, with beer-battering lowering the hardness from 3394 g force to 2619 g force, and increasing the quantity of fractures from 87 to 113.

Sensory evaluation

Table 3 provides explanations defining the four sensory attributes under investigation, whereas Fig. 3 shows the result of the evaluation for two food items coated and fried with four different batters. Overall results indicate that there is very little difference in sensory attributes between the high-protein fish fillets and fat-free onion rings when they are coated and fried using the same batters from rice flour, modified rice flour or wheat flour, with and without beer. However, in comparing each category of the attributes for both the fish and onion samples, items fried with batters formulated with modified rice flour were significantly harder and crispier than those formulated with wheat flour, which agrees with results from instrumental textural analyses as described earlier. They also had greater fracturability and toothpacking. Specifically, crispness was affected by modified rice flour over wheat flour more than the other three texture attributes. Overall, the formulation with water was not significantly different from that with beer for any of the four texture attributes, although hardness appeared to be slightly less with beer than with water on both fish and onions, which agrees with results as described above for instrumental textural analysis of the fried batters.

Table 3. Sensory texture attributes

Hardness	Force required to compress the food 1.0 = Philadelphia cream cheese, to 14.5 = Life Saver hard candy
Fracturability	Force with which the sample breaks 1.0 = Jiffy Corn muffin, to 10.0 = Finn crisp rye wafer
Crispness	Force and noise with which a product breaks or fractures 3.0 = Quaker low-fat chewy chunk granola bar, to 17.0 = melba toast
Toothpacking	Degree to which product sticks to the surface of the teeth 1.0 = uncooked and unpeeled carrots, to 15.0 = Ju-Jubes

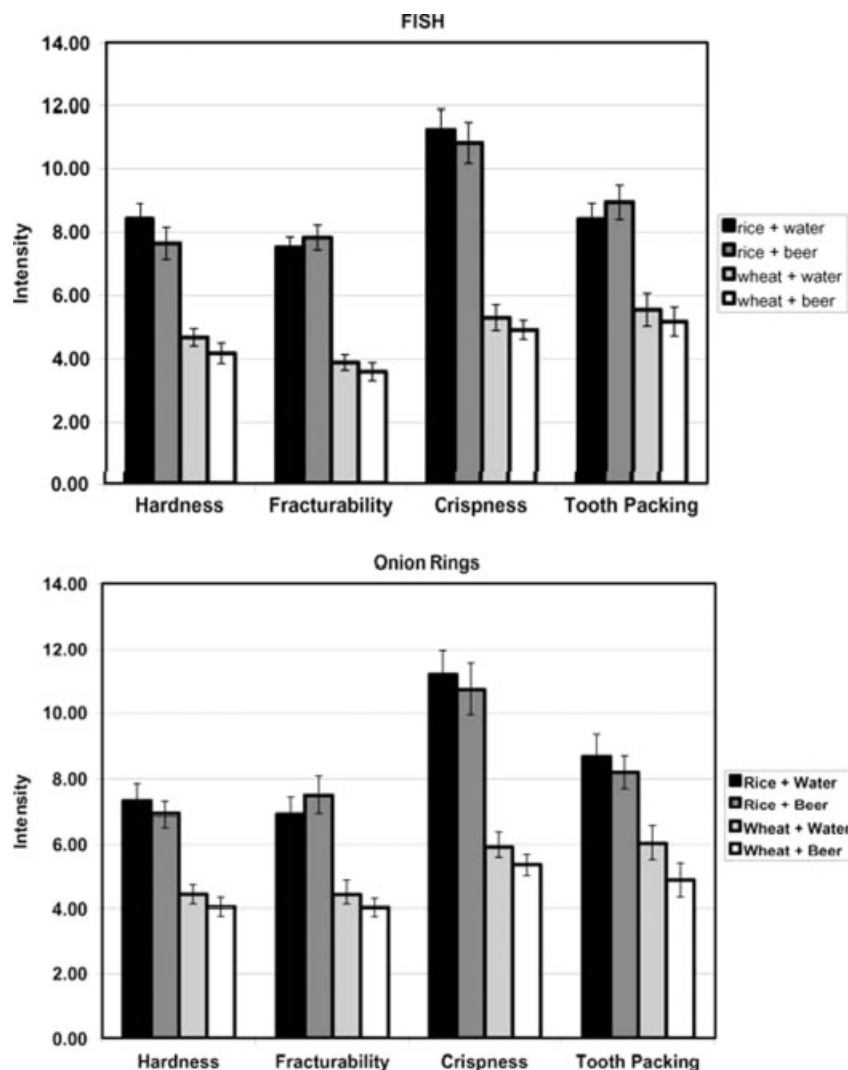


Figure 3. Sensory evaluation for fish and onion rings coated and fried with four different batters.

CONCLUSIONS

The use of beer in batter formulation causes an increase in the oil uptake of the batter during frying. In general, both instrumental textural analysis and sensory evaluation indicate that fried batters with beer are slightly softer but crispier than without. The effects are more pronounced for rice batters than wheat batters. Particularly, with or without beer, the values of oil uptake during frying are substantially lower for rice batters than wheat batters.

REFERENCES

- Saunders L, *Cooking with Beer*. Time-Life Books, Alexandria, VA (1996).
- Sasiela RJ, Troubleshooting seafood products. *Food Ind J* **5**:125–155 (2002).
- Annapure US, Singhai RS and Kulkarni PR, Screening of hydrocolloids for reduction in oil uptake of a model deep-fat fried product. *Fett/Lipid* **101**:217–221 (1999).
- Holownia KI, Chinnan MS, Erickson MC and Mallikarjunan P, Quality evaluation of edible film-coated chicken strips and frying oils. *J Food Sci* **65**:1087–1090 (2000).
- Han J-A and Lee M-J, Lim S-T, Utilization of oxidized and cross-linked corn starches in wheat flour batter. *Cereal Chem* **84**:582–586 (2007).
- Shih FF, Bett-Garber KL, Daigle KW and Ingram D, Effects of rice batter on oil uptake and sensory quality of coated fried okra. *J Food Sci* **70**:S18–S21 (2005).
- Shih FF and Daigle KW, Oil uptake properties of fried batters from rice flour. *J Agric Food Chem* **47**:1611–1615 (1999).
- O'Connor CJ, Chen KS, Smith BG and Melton LD, Factors affecting lipid uptake in battered hoki fillets deep-fried in tallow. *Food NZ* **1**:S1–S8 (2001/2002).

- 9 Fasano A and Catassi C, Current approaches to diagnosis and treatment of Celiac disease: An evolving spectrum. *Gastroenterology* **120**:636–651 (2001).
- 10 Cato L, Gan JJ, Rafael LGB and Small DM, Gluten-free breads using rice flour and hydrocolloid gums. *Food Aust* **56**:75–88 (2004).
- 11 Kim HR, Kim KM, Chung SJ, Lee JW and Kim KO, Effects of steeping conditions of waxy rice on the physical and sensory characteristics of Gangjung (a traditional Korean oil-puffed snack). *J Food Sci* **72**:S544–S550 (2007).
- 12 Meilgaard M, Civille GV and Carr BT, *Sensory Evaluation Techniques* (4th edn). CRC Press, Boca Raton, FL (2007).
- 13 Mohamed S, Hamid NA and Hamid MA, Food components affecting the oil absorption and crispness of fried batter. *J Sci Food Agric* **78**:39–45 (1998).
- 14 Ward FM and Andon SA, Water-soluble gum used in snack foods and cereal products. *Cereal Food World* **38**:748–752 (1993).
- 15 Pinthus EJ, Weinberg P and Saguy IS, Oil uptake in deep fat frying as affected by porosity. *J Food Sci* **60**:767–769 (1995).